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The Prismatarium

Conservation of Hilaire Hiler's Phychological Color Chart Room at the Aquatic Park Bathhouse
National Park Service Maritime Museum, San Francisco
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Background of the Bathhouse and Prismatarium:

The Aquatic Park Bathhouse, a National Historic Landmark building, is located at 900 Beach Street, at the foot of Polk in San Francisco. Set near the water's edge of Black Point Cove, the building was constructed between the years of 1936-39 under the auspices of the Works Progress Administration. The Bathhouse was part of a larger plan to revitalize the entire shoreline with a new breakwater, sandy beach, speaker towers, bleachers and concessions. The Bathhouse building would provide needed interior spaces devoted to a lobby, restaurant, lounges, restrooms, lockers and showers.

Architects William Mooser Sr. and Jr. created a unique structure which, with WPA funding of the project, made possible the unusual amount of artistic embellishment of the building. The Bathhouse is an outstanding example of the collaborative work of diverse artists and tradesmen, working in stone, terrazzo, metal, mosaic, applied ornament and paint, at a time when craft was supported and appreciated.

The decorative accoutrements supported the overall curvilinear style of the building, broadly termed "late Art Deco" in style. In more descriptive parlance, the building is also referred to as "Streamline Moderne." The structure as a whole flows in curves and stepped layers. At first glance it resembles a modern sea-going vessel at dock. The ends of the building are rounded, with a rectangular middle section, porthole windows, multiple decks, and a pilot-house on top. Great attention was paid to the detail of lighting fixtures, door handles and hardware, wainscoting, tray ceilings, picturesque floors, murals and wall decorations; the décor is interwoven into the theme of nautical activity and marine life. Large windows within minimal steel frames incorporate the movement within the bay as part of the experience of the building. The intention was to offer the public a modern, beautiful and entertaining place to gather.

The lead artist on the project was Hilaire Hiler, who designed the murals in the main lobby and the Prismatarium. These two areas became his best known works, in addition to his authorship of books on color theory. Other artists such as Richard Ayer, Benjamino Buffano, Sargent Johnson and Charles Nunnemaker carried out commissions in other parts of the building in concert with Hiler's overall artistic vision.

Description of the Prismatarium:

The Prismatarium is the former Ladies Lounge at the west end of the Bathhouse, on the second floor, the main entry elevation from Beach Street. It was in later years also called The Steamship Room during the time the National Park Service used the room for exhibitions of historic marine artifacts. It is a circular room of approximately 54 feet in diameter, with windows occupying almost two thirds of the room. The ceiling is painted to represent Hiler's color wheel. The walls and support columns between the windows are painted as a gray scale, ranging from light at the ceiling to dark at the floor. The room is a virtual representation of Hiler's color study, laid out in the systematized manner proselytized by the artist in his several books on color theory.

The background Hiler brought to this work is fairly well documented; he was an artist, psychologist, musician, former expatriate, and color theorist who studied and experimented with the prevailing color theories of his day in both the United States and abroad, finding most of them lacking. He claimed his ideas were based on human perception or sensory (*sensed*) relationships to color, what the eye actually perceives, and colors relative to one another. His views stand counter to most of the traditional schools of teaching about color and painting, much of which is based upon the chemical or physical properties of pigments. Hiler believed that the artist's use of color depended upon "relative assessments," and that aesthetics belonged to the study of psychology and not to the study of physical properties.

The Ceiling:
Hiler's suggested manipulation of the color wheel into a system of 30 basic color standards is the basis of his ceiling mural. His description of this, as well as his formulation of Tones, Shades and Tints, and a 12 step Gray Scale, is described in his later book entitled Color, Harmony and Pigments, published in 1942, by Favor, Ruhl and Company, Chicago.

The Prismatarium ceiling starts as a band of color surrounding a central round art deco chandelier. These are 30 color "standards" representing the solar spectrum (like a rainbow) which are painted in wedge-shaped spokes radiating outward (and increasingly broad) to the walls and windows. The spokes are broken into variations of the starting 30 colors by five concentric bands around the chandelier (as would the circular waves surrounding a drop of water in a pool.) The bands are also narrower near the center and become larger as they approach the windows. As a whole, the colors of the ceiling compose a fan-shaped spectacle.

The first band of "standard" color around the chandelier is followed by tones, shades and tints of the color, finally repeating the starting color at the outer edge and vertical wall surface just below the ceiling. Where the concentric bands begin and end, the plaster ceiling actually steps down physically by about one inch from the center ceiling level where the chandelier hangs. These steps help define the concentric banding. The round shape of the room lends itself perfectly to the fan-shaped sequence of colors, and the level changes. The black terrazzo floor is inlaid with metal lines, which exactly mirror the color blocks on the ceiling; there are 30 divisions on the floor with five concentric bands; it is as if the floor were a map of the ceiling color fields. The incorporation of the mural design into the architecture is seamless, unexpected, and sophisticated.

Part of Hiler's recorded plan was to have a rotating prism at the center of the chandelier, to add further variation to the painted colors. The whereabouts of this prism or any factual evidence of its existence, however, is unknown.

The Walls:
The walls of the room compose a neutral gray scale. The lightest color actually starts on the soffit above the windows. The next lightest gray is painted in a rectangular block at the top of the walls and the columns, gradually becoming deeper and darker shades of gray as the blocks step down. Three columns break the 5 sections of windows, spanning north to south. The curved east wall, unbroken by windows, has only three bands of light-to-dark neutral gray, and may indicate that the project was unfinished. A workers' strike near the end of construction may have interrupted the finishing of this wall. Near the floor, the last three color bands are trimmed with three strips of lighter grey wood moldings to create a wainscot. Original sconces of white glass and white metal, art deco in style, encircle the walls and columns.

EXAMINATION AND CONDITION REPORT:

Structure and Condition: Gray Scale Walls

Canvas:
The walls of the Prismatarium are constructed of poured concrete, with a traditional lime plaster laid over expanded metal lath. The plaster surface is glue sized, then covered entirely (walls and ceiling) with a medium weight linen (bast fiber) canvas, attached with a glue-paste adhesive.

The condition of the canvas support for the gray paints is generally good; however, there is extensive deterioration around the window casings and outer edges of the soffit. Numerous areas are detached, lifted and curled. After years of using center-draw traverse drapery rods at the windows, and vertical cords operated through tension pulleys, the detached canvas was sometimes tangled in the hardware, causing some tears and losses in

the corners of the columns. The penetrations through the canvas by hardware also caused lifting, shredding and distortion of the canvas. There are stains and accumulated grime along the tracks of the former drapery rods.

Stacked drapes at the sides of the columns (when opened) trapped moisture, which further exacerbated the effects of dampness. Direct penetration of rainwater at the edges of the metal window casings not only caused canvas detachment, but decay of the plaster beneath. Efflorescence caused expansion, cracking and powdering of the plaster. The plaster spauled in many areas, leaving voids in the walls; wet/dry cycles caused further deterioration of the paints, which flaked off, leaving the weak and distorted canvas with numerous paint losses.

The recent installation of new windows, casings and shades caused additional fracturing of the support plaster, and some of this fell away. Loss of adhesion of canvas also occurred. Several sizeable losses of canvas are found in locations where plaster loss was severe. Some former repairs were evident where there were cut-outs of canvas on one of the columns and a few cut lines in the canvas where canvas was reattached. Work done by Architectural Resources Group just before window installation mitigated some of the wall weakness and canvas distortion.

Priming:
The walls were primed with a white emulsion paint (oil and protein), over which was painted a light gray color in oil binder. The wood wainscot was similarly primed without the canvas; the light gray paint was left as the presentation layer.

Paint Film:
Over the emulsion priming, the light gray oil color exists over the entire column and wainscot. The bottom ten steps of colors on the columns were then painted with the darkest charcoal color, consisting of Prussian blue and black in oil. Each gray scale step starting from the floor upward was then lightened with greater percentages of white, and fewer parts of Prussian blue and black. The last two (top) steps of the scale were not painted with the dark charcoal color below, but were simply painted in the light colors required over the light gray oil paint.

The conservators discovered during work with the grey walls and ceiling soffit, that the paints higher on the wall, the priming, and the soffit contain lead. This probably indicates white lead as the primary additive to all the grays and priming. Simple commercially available red-dye indicators for lead, although not conclusive for concentration, tested highly positive in every test sample.

The gray paints differ in degree of surface gloss. Since there appears to be no varnish film on the walls, the composition of the paints appears to vary in proportion of pigment to binder, or they have deteriorated more with higher concentrations of lead, or they deteriorated in other anomalous ways. Fading is less of a problem for lead, Prussian blue or black than is the deterioration of the oil binder, which would cause de-saturation of the

color and dullness. A matte or very soft sheen is generally characteristic of the upper 5 or 6 color bands, and then the lower portion (the wainscot) appears to be stronger, more completely bound and glossier than the rest, especially on the east wall.

The color bands on the southeast wall near the south-most window are remarkable for not being in the original correct stepped order (light to dark). Solvent tests on the wainscot on the east wall indicate some lighter charcoal grays beneath the topmost layer; this leads to a reasonable assumption that the lower parts of the wall have been re-painted at some time. This holds true for the wainscot, also. There are no corroborating visual or written records describing the original painting of this room, nor of any other conservation interventions.

The worst areas of paint failure are, of course, nearest the window casings on the outside edges of the columns and the soffit. Drapery at the windows was effective in slowing the process of paint deterioration to some extent, but natural light and heat exposure in the room was severe for many years prior to the recent installation of window shades. There was also a gap between the windows and the set-back of the curtains, where the paint was entirely unprotected. In these locations at each window the paint/binder is extremely deteriorated; it is all but diminished to powder, being excessively desiccated, and friable.

Wainscot:
The three bands of wood running around the room help prevent the scuffing of walls with furniture, and act as a benign physical barrier to help prevent people leaning against the walls. These painted wood strips are splintered, gouged, soiled and have been rubbed to the point of exposing the wood grain in some areas. A great quantity of water staining (perhaps condensation, perhaps from periodic cleaning) is found on the wood banding, and a great accumulation of soil and brownish debris is found on the top edges of the rails.

Surface Coatings:
There was no varnish or clear coating on the Prismatarium walls or soffit. One of the major disfigurements of the gray walls is the array of drip stains due to condensation, visible mostly at the top of the wall just beneath the vertical color band, especially along the east wall, but found throughout the room. The staining terminates in brownish beads of soluble surface grime. The streaks are mainly glossy, with blanched color noted between the drips (probably general decay of paint binder). Streaks below the heating vents indicate metallic and/or insoluble salt deposits as well.

The soffit has a line of similar beaded brownish stains deposited at the inner edge (away from the windows, similar to that found on the wainscot). The NPS heating engineer suggested that even the smallest faulty leak of the steam valves in the room would put enough moisture in the air to cause the quantity of drip staining found in the room. Further, vents to the outside below the windows have been variously closed and opened over the years, allowing moisture from outside to enter uncontrolled into the space.

The two heat registers in the room are responsible for the great local accumulation of greasy black soot found in large halos on both walls and ceiling. There is no filtration of return-air ducts or heat registers in the room. Soot or the results of heat are found in streaks rising from the sconces.

Cloudiness is generalized, and there are noticeable accumulations of hand soil, and markings due to impact.

TREATMENT OF WALLS AND SOFFIT:

Plaster and Canvas:

Plaster repairs were made by first removing any lifted or broken plaster around the window casings, columns, and holes made for drapery anchors. Some of this work was done by Architectural Resources Group prior to the window replacement; however, the window work caused a considerable amount of additional fracturing of the plaster, and coincidental lifting of canvas.

Shallow losses of plaster were repaired with vinyl spackle (Crawford's, patching compound). Deeper losses were primed with acrylic primer (Dynamite brand 221, Acrylic Primer and Sizing). Areas of patching were then primed again and the canvas reattached with the strongest of the cellulose-based adhesives for the window exposure (Dynamite Clay-Based Strippable Adhesive, 433.) Patches of pre-primed commercial artists' painting canvas with similar weave were used to patch the largest losses in the canvas, using the same priming and adhesive. Small separations of canvas from the wall were corrected by hypodermic syringe injection of adhesive. Two pin-sized pilot holes were required (one for outlet of air, one for delivery of adhesive). In this way, the walls were stabilized and prepared for the cleaning procedure.

Cleaning tests:

The challenge imposed by the cleaning of the walls was considerable. Each section of paint represented a uniform color field, which could be spoiled by uneven cleaning, lap lines, or thinning of paint by use of active solvents, friction, inexact timing of applied solvents, and/or their removal. Achieving a uniform surface after cleaning a friable color field is difficult, if not impossible, and is further complicated by the need to remove hard stains or debris, requiring repeated handling of the surface.

Cleaning solvents of all sorts were tested in combination with numerous delivery methods. The conservators were aided by Richard Wolbers of the University of Delaware Conservation Training Program, (specialty in historic paint finishes), who was the consultant on the project. Aqueous and organic solvents, acids, bases, gels, chelating agents, and mechanical means of cleaning were all attempted. Prior consolidation of the paint films to stabilize deteriorated paint prior to cleaning efforts was explored. In every instance, the gray paint films disintegrated to a more or lesser degree and were thinned,

exposing some disturbing amount of the priming below. It was impossible to achieve an even surface, as the topmost layers of paint became powdered (pastel-like) in treatment; they were smeared or removed in the cleaning effort. Inpainting, with additional sprays of picture varnishes to help attenuate the visual disturbances, was not successful enough to produce a crisp and uniform color block with consistent sheen, or to cancel out the many vertical drips within the horizontal composition.

The decisive factor to re-paint the walls, however, was not just the visual difficulties presented, but that the paint itself had a substantial lead content and was powdery enough to present long-term exposure risks. Public spaces require lead abatement or encapsulation in this case, so as not to threaten health and welfare of staff workers or visitors. The surface would not become stable enough with a picture varnish coating to be sustainable; maintenance of the walls against traffic, handling, and periodic cleaning would not be possible. The friable surface needed to be sealed completely.

Richard Wolbers helped formulate the layering system of coatings needed to mitigate the problem of lead exposure. His suggested protocol reached consensus with the conservators, NPS staff, and the office of the State Historic Preservation Officer.

Recent research by Wolbers concluded that application of a coating called Avalure AC315 (acrylate copolymer, Lubrizol Advanced Materials, Inc.) resin to the walls would serve to chemically bond the lead, essentially "locking up" the reactive molecular portion of the lead, while keeping it firmly in place on the wall. This would preclude the need to strip the canvas from the walls, or continued work to clean off the various dirt films, which are fortunately similarly encapsulated by the Avalure. The Avalure coating would be followed by a shellac-based primer (Zinsser B-I-N) in the same diluent (ethanol), followed by the final layer of eggshell latex paint by Benjamin Moore.

Repainting the Walls:

Repainting the walls with appropriate colors was achieved in part by first measuring the colors of the walls with a colorimeter (Minolta CR 221). The l-a-b numbering system was used ("l" measures light to dark, "a" measures red to green, and "b" measures yellow to blue.)**.** The soffit (lightest gray) color and the last dark charcoal color at the bottom of the wall were measured on-site after cleaning a portion of each. (The explanation of the method of determining the colors to be painted, as nearly as Hiler intended in equal steps, is found in the appendix). Wolbers found the soffit color, by matching it first to a standard color offered by Benjamin Moore, within the tolerances the eye can see according to the colorimeter readings. He did the same for the darkest charcoal gray. Then by adding progressively more dark paint to light by weight, he produced a scale of 12 equal steps, confirmed by the colorimeter after drying.

The small 12 step spread-out sample of colors made by Wolbers was then read by the computer matching system at Benjamin Moore, and the custom matches were mixed in large quantity for the painters. These new mixed paints were then spread-out on standard

test sheets again and they matched favorably to the smaller Wolbers sample, to the satisfaction of the conservator, painter and NPS staff.

Given the aging of the original wall paints, with their collections of soot, light and heat exposure and past repainting in parts, they have undoubtedly changed dramatically over the years. One may never have an exact match to the original color intended by Hiler, but his writing on the subject directed the method used to create the new painted surface, which is a system of equal steps over 12 surfaces from light to dark, using matches of the lightest light and the darkest dark found on the walls.

Structure and Condition: **Ceiling**

Numbering System:
For purposes of identification, the 30 wedge-shaped standard colors are numbered 1-30, starting with number 1 just to the left as one enters the room. The numbers proceed in order clockwise from east, south, west then north.

The concentric color bands are lettered “a” (or sometimes “v” on the colorimeter readouts) for the vertical band at the top of the wall nearest the soffit. This is the band at the outer part of the wall at the windows or east wall/ceiling interface. The other bands, coming toward the center, are “b”, “c”, “d” “e” and “f”. “F” is the center band surrounding the chandelier. The bands “a ", and b” are intended to be repetitions of the standard colors in band “f”.

The Colorimeter:
Colorimeter readings in the l-a-b numbering system were taken of each segment of color prior to the start of work.

Support:
The plaster surface of the ceiling was applied by hand, and as such is slightly undulating, causing an almost unnoticeable flicker of light or darkness due to cast shadows and highlights, which change throughout the day. The ceiling is covered entirely with a medium weight linen (bast fiber) canvas, attached with a glue/paste adhesive, as are the walls. The joins in the canvas are not always aligned with the design, and sometimes run off at odd angles, which are faintly visible from the ground.

Analysis shows (see appendix) that the canvas is sized with a protein-containing material (probably a natural glue size), and is packed with a white material bound in oil. Over this is a sealing layer (again probably a glue size), which also shows some oil content.

Priming:
The canvas is at least doubly primed with emulsion paint, composed of oil with protein, packed with white pigment. The topmost layer has a higher percentage of protein to oil

with white pigment, and in at least one sample contains gum as well. The priming has small trapped pockets of air in its structure, possibly indicating an aqueous binder like distemper, casein or casein with emulsified oil (see appendix). These types of paints are generally more sensitive to aqueous solvents, and friction, and may account for some of the difficult handling of the surfaces during cleaning.

The color bands: Standards, tints, tones and shades:
According to Hiler, the standard colors at the center were modified by mixing them with black, white, or black and white together. He called *tints* the product of mixing the standard color with white. *Shades* are standard colors with white and black added. *Tones* are produced by the standard color plus black. In the appendix of this report are the results of polarized light microscopy, done in an effort to determine which bands of color represent the tints, shades or tones.

What has been discovered is that there are contradictory findings in this color wheel, and that Hiler (or his assistants) did not strictly follow the ordered system as Hiler wrote later. For example, all the bands of one standard test color (one spoke) indicate the presence of white pigments. Since Hiler was most interested in color as a *sensed* or *perceived* phenomenon in relationship to others, there were perhaps liberties taken at the time of the painting to alter color with whatever pigments were necessary to produce the desired effect. Oddly, there are some colors which today look entirely "wrong" for their location, and seem to be out of the expected order. Knowing which pigments were used does not tell the full story of why they were chosen or mixed as they were, or in what unusual ways the colors have been altered by time.

Polarized light microscopy identified dark pigments and dark dyes in band "c." Because there are white pigments in all bands "c", "d" and "e", it seems contradictory to name the "c" band as the band of "tints", even though it looks to be the lightest band. The analysis is inconclusive given the few samples tested. Visual discrimination, however, does appear to identify the "c" band the *tint*, the "d" band the *shade*, and the "e" band the *tone*, but this is not certain.

Paint Layers:
The paint samples taken for study indicate only one thick application of color for the presentation layer of the mural. The analysis of this paint indicates a strong presence of oil, but also contains copal resin, gum and protein. The location 20e indicates a strong positive test for gum in addition to oil, and sample 30e shows gum and protein in addition to oil. (The paint mixtures may vary greatly one to another, but this would not be known unless they were tested individually). The test paints are dense with color, but lean, having little binder, possibly due to sinking into the primer. This characteristic would account for the physical weakness of the paint generally, and the extreme sensitivity of the paint to solvent action.

Further complexity in understanding the mural comes from the two different palettes of color Hiler suggested for painting; one was meant for use in fine art painting, and one for "decoration," such as typically used for large scale projects in buildings. The palette for "decoration" is composed of more fugitive and inexpensive colors. The microscopy indicates that the paints used in the Prismatarium were probably the latter, in part because they were commercially prepared (not hand ground, with small particle sizes), and that dyes consisting of bright blue, and red to magenta, are also present. Conversely, cadmium reds and yellows were used (see appendix) and these belong to the palette of fine art colors.

Most of the color fields are intact, but they are beneath a varnish coating, which may account for their stability; they may be partially bound together by the coating. There are many panels exhibiting traction and age cracks, and yet are stable. Traction cracks may be due to the timing of the application of the paints and/or primers and sealers, or due to the separation of the colorants from the binder.

The most severe deterioration of the color fields is characterized by fractured paint which has lifted into many tiny islands, with the varnish film in similar condition. Much of this condition is found in locations nearest the windows with western exposure. Light and heat may be responsible, but also moisture penetration is likely a contributing factor. Above the ceiling is an exterior tile patio where rainwater may have collected. Some of the yellow colors appear to be water stained, or at least, their pattern of deterioration is similar to water seepage in the symmetrical partner-room at the opposite end of the building.

Zinc was found to be substantially present in one of the color fields. Zinc is notorious for instability over time. It is additionally fragile in the presence of lead, which may also be present in some of the color fields. This may account for some of the anomalies found in cleaning, and for some of the color instability. It may also account for some of the colors looking oddly out of expected order.

It is not possible at this time to make a generalized statement about the composition of each color field, nor to make sweeping statements about chemical interactions within the fields. Several observations that seem to be obvious hold true: the colors are deteriorated more where exposed to direct sunlight, and are more faded in those locations. Further, vertical surfaces seem to be more deteriorated than horizontal ones for this reason, unless they are shielded from light (as are the stepped portions of the trayed ceiling and verticals on the west-most locations). The field 30b, just inside the door has flaked badly, and this is probably due to the frequent and severe relative humidity changes in that location. The interface of the ceiling with the vertical band ("a" and "b") is largely protected from light (except on the east wall), yet some flaking is more severe in the northwest exposure than elsewhere. Again this may be due to relative humidity changes or sites of condensation within the room, or patterns influenced by the vents and heat registers. There are such variables presented by this mural that only further physical and chemical analysis would explain.

Hiler's execution of the mural may not exactly follow his theory, and some of the mixing may have been spontaneous, subjective, or may have been done partly during his absence. There is also the cost and availability of color Hiler may have experienced when formulating the color wheel. He may have had to "make do" with fewer or lesser quality products than he preferred.

Surface Coatings:

The first and most obvious alteration to the mural is the great quantity of surface soil which prevents the viewing of the relationships of the colors; they appear to be closer in hue and value than intended. Halos of blackish soot found above the heat vents and sconces add to the generalized soil. The composition of the debris is probably a combination of fossil fuels from heating, from street traffic coming through the vents, and nicotine.

Beneath the soot layer is a substantial coating of varnish, applied liberally, and unevenly. This film, which would have been clear at the time of application, is much discolored and can be readily seen in patches covering the entire ceiling (with the exception of the gray portion behind the chandelier). The application was by hand brushing, but applied without regard to direction or uniformity; some color fields were applied in a vertical direction, some in a horizontal direction, with very obvious lap lines and holidays. The disturbing visual effect of this coating cannot be understated. It alters the color of each field, and it breaks the fields themselves so that they cannot be viewed as solid color blocks. In some areas, the coating looks to be blanched, and imposes multiple colors within each field. The varnish imparts a soft sheen, but it is somewhat uneven due to the variations in application and condition. Undulations in the plaster add to the uneven reflections of light from the surface.

The varnish film was applied some time after a light accumulation of soil formed on the ceiling, as evidenced by paint samples from spoke 15. Not surprisingly, there were salt accumulations on the paint film in the test samples. Lack of saturation of the colors due to salt formation may be the reason for applying the varnish coating. The presence of salts on the surface of the paint would cause the color scheme to look lighter and less saturated, and would be remedied (at least temporarily) by applying a saturating finish of varnish. Moisture seeping through the patio above may be the source of these salts, and coating the ceiling may have been the misguided effort to "seal" or "preserve" the mural. In fact, the coating would exacerbate the problem of trapping moisture into the lower layers which are the least resistant to moisture, causing some of the flaking problems observed.

The varnish film is highly insoluble and discolored. The film shows an FTIR spectrum consistent with copal resin from Zanzibar, as well as an alkyd resin with cobalt drier. These components would be expected to darken and yellow over time, to cross-link and become increasingly insoluble to chemical agents.

TREATMENT OF THE CEILING:

Cleaning:

Cleaning tests were made in a number of small locations with variable success. The most common result was the fairly rapid reduction of surface soil, but with bleeding of color and little removal of the varnish coating, except where it is severely deteriorated. Polar solvents in particular were dangerous to use on the color fields with soluble dyes, and these seemed to be the only solvents which could be expected to act upon the varnish film (with long exposure and friction). Uncontrollable bleeding of the dye occurs with very little provocation.

These results are consistent with what is known of the materials through the analytical work. The canvas is bound to the plaster with a water sensitive material, as is the priming of the canvas and surface preparations. The paint films are variously sensitive, and the varnish resists removal. The surface soil is easily removed with aqueous products, but this moisture activates and weakens the painting structure as a whole. Organic solvents do little to diminish the surface soil; detergents of all kinds are too active and are not easily removed without undue use of water.

A solution which could be most easily applied and removed, using the lowest threshold of reactivity needed for the cleaning was a gelled solvent. This gel was also least reactive to the varnish and paint and consisted of Pemulen (block co-coacrylic, C15-30 acrylate ester) and triethanolamine in the following proportions:

100 ml Deionized water
1 gr. Pemulen TR2 (Noveon)
6 ml triethanolamine (Sigma-Aldrich)
pH 8.5

The general usefulness of this product was the gelling property of the Pemulen. This permitted use of a dilute aqueous cleaner in a safe range of pH, in a form that would suspend the agent in contact with the surface rather than wetting the structure through. Also, this gel can emulsify and suspend the soil, so that it can be removed from the surface and dried as quickly as possible. (See appendix).

Once the Pemulen gel was found to be effective in removing the soil, alterations were sometimes made by decreasing the amount of triethanolamine. Application was made with foam sponges, and the surface was wiped clean of gel and soil with soft paper towels. Later, the brushes were replaced by flat soft fiber trowels made for painting, which helped remove the gel more quickly. Lap lines were always a problem, as the cleaning could only be done in small blocks due to the necessary timing of surface contact and removal. Although this cleaning method was the best match for the situation, it required very careful handling. Some unavoidable situations (such as overly sensitive

color fields) could not be avoided. Further, some parts of the varnish film were deteriorated or uneven and this could not be seen beneath the surface grime. In some color fields, it became obvious that the paint was composed of different colorants that separated during cleaning, or they were exceedingly lean due to the flaking of the paint surface along with the flaking of the varnish.

On some of the color fields the varnish was so badly deteriorated that it could be removed partially by vacuum cleaning. This was especially true of section 24, which was cleaned almost in its entirety by vacuum cleaning. Where varnish was absent, the cleaning procedure unavoidably removed some of the paint film, as the paint had virtually become pastel. This was the same problem encountered in the cleaning of the walls.

Typically the paint film appeared blanched after vacuum cleaning, but the cleaning process revealed the bright color again (a salt layer may have been removed in the process). Some of the sections, such as the yellow and orange cadmium colors presented a health hazard, as they were extremely flaky and lean. Paint dust was contained by proper suiting-up as for lead abatement, and by dropping plastic sheets surrounding the areas to be cleaned. Floors as well as lift equipment and conservator's clothes were thoroughly cleaned after each session, and the plastic rolled up and carefully disposed of when finished.

Areas of flaking paint were consolidated with small brush application of Aquazol 500 (poly 2-ethyl-2-oxazoline) prior to cleaning. Lifted paint was pressed back into position through silicone release mylar.

The worst areas of deterioration of the paint film were between spokes 14-21. Several of these had considerable paint loss due to the flaking of the paint with the varnish, the softening of the paint, and the unavoidable need to remove the cleaning gel. The physical problems were very similar to those experienced by cleaning the gray scale walls. The results, however, were still remarkable, and cleaning was a better choice than repainting, achieving a more natural appearance with the adjacent color fields.

Varnishing and Color Compensation (Inpainting):
Once cleaned, parts of the ceiling with very lean but stable pigments were brush coated with Golden satin MSA acrylic varnish in VMP Naptha. This process would sometimes change an area somewhat by saturating the color. Large areas such as those between spokes 14-21 were spray coated with an industrial sprayer, as they required a binder to consolidate the paint layer to the ceiling. This resin will transmit enough moisture to permit breathability of the surface. Other areas required only very small localized applications of varnish, and this was done by brush or by small airbrush.

No polar solvents such as water, alcohol or acetone could be applied over the paint film. One blue vertical (3a) was wiped with alcohol to remove an Avalure test coating, and this caused the varnish to "flash", blanch white. Richard Wolbers felt that the original varnish must contain stearates which, if exposed, are very difficult to remove or cover.

Polar solvents are a choice to avoid on this mural for this reason, and for the related problem of causing dyes to bleed.

Losses in the paint film that could be noticed from the floor were filled with vinyl spackle before inpainting.

Inpainting was done with a combination of materials. Small losses of paint were inpainted with Gamblin Restoration colors, in naptha/acetone or iso-propanol. Where needed to help match the surface, the losses were further finished with an application of MSA varnish (solutions of satin to gloss).

The challenge of inpainting the ceiling was to achieve as uniform a surface as possible, both in color and surface sheen. The surface was largely blotchy by virtue of the old, uneven varnish coating, some modest contributions from the cleaning process, and the new applications of varnish. New varnish was helpful where color saturation was needed, but this could be easily overdone, presenting new problems, or changing color relationships. Lighting affected every color choice and every choice for surface gloss; adding to the difficulty, the angle of viewing and lighting is constantly changing. Achieving a reasonably clean looking surface without drawing too much attention to the variations in color within the color fields required compromise in treatment.

The great visual disturbance of the old discolored and cloudy varnish could not be mitigated by inpainting with traditional mixed paints. The areas were too large and the inpainting medium could not be controlled short of repainting large sections. Rather than modifying the color fields with opaque applications of color, an effort was made to diminish the discolorations with translucent and easily reversible colored pencils (soluble in mineral spirits).

The most lightfast colored pencils by Prismacolor (Premier) were effective, as they could be blended dry without disturbing the varnish or paint surfaces below. The sheen was very closely matching the original varnish, which was left in place wherever possible.

Recommendations:

Environmental Concerns:

There is continued concern that the environment within the room is not thoroughly understood, nor controlled. Keeping the temperature and relative humidity stable will require keeping the doors closed as much as possible, while finding the right balance between air intake from the outside and the interior heating, or lack of heating. Filtration of air vents and heat ducts should be put in place to prevent the collection of airborne soot on the walls and ceiling. Minimal wattage of lamps and lighting should be used. Shades should be kept down as much as possible to control heat and light damage.

Use of the room, if continued to be rented to outside parties, should require that additional lighting be kept minimal. Large standing light fixtures or direct lighting of the ceiling may cause damage by heat, fading of inpainting media, or be a hazard that can be tipped over. Reasonable caution should be observed. A representative of the NPS should be available before and after any event to record any new damages, so that these can be rectified as soon as possible.

Inspection of the condition of the walls and ceiling should be done at least every five years. The NPS staff should meanwhile be aware of any leakage after rains, or any standing water on the room. Continued monitoring with the data logger will bring knowledge to bear on the long term needs within the room.

The old varnish will continue to age and deteriorate. Signs of this require further investigation, or perhaps dry removal, as possible. Unfortunately, the use of an inappropriate varnish coating on this ceiling will continue to be a major factor in the conservation/restoration possibilities of this mural.

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